

Nutrition for Space Exploration

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Nutrition has proven to be critical throughout the history of human exploration, on both land and water. The importance of nutrition during long-duration space exploration is no different. Maintaining optimal nutritional status is critical for all bodily systems, especially in light of the fact that many are also affected by space flight itself. Major systems of concern are bone, muscle, the cardiovascular system, the immune system, protection against radiation damage, and others.

The task ahead includes defining the nutritional requirements for space travelers, ensuring adequacy of the food system, and assessing crew nutritional status before, during, and after flight. Accomplishing these tasks will provide significant contributions to ensuring crew health on long-duration missions. In addition, development and testing of nutritional countermeasures to effects of space flight is required, and assessment of the impact of other countermeasures (such as exercise and pharmaceuticals) on nutrition is also critical for maintaining overall crew health.

Vitamin D stores of crew members are routinely low after long-duration space flight. This occurs even when crew members take vitamin D supplements, suggesting that vitamin D metabolism may be altered during space flight. Vitamin D is essential for efficient absorption of calcium, and has numerous other benefits for other tissues with vitamin D receptors.

Protein is a macronutrient that requires additional study to define the optimal intake for space travelers. Administration of protein to bed rest subjects can effectively mitigate muscle loss associated with disuse, but too much or too little protein can also have negative effects on bone. In another bed rest study, we found that the ratio of protein to potassium was correlated with the level of bone resorption: the higher the ratio, the more bone resorption. These relationships warrant further study to optimize the beneficial effect of protein on both bone and muscle during space flight.

Omega-3 fatty acids are currently being studied as a means of protecting against radiation-induced cancer. They have also recently been implicated as having a role in mitigating the physical wasting, or cachexia, caused by cancer. The mechanism of muscle loss associated with this type of cachexia is similar to the mechanism of muscle loss during disuse or space flight. Omega-3 fatty acids have already been shown to have protective effects on bone and cardiovascular function. Omega-3 fatty acids could be an ideal countermeasure for space flight because they have protective effects on multiple systems.

A definition of optimal nutrient intake requirements for long-duration space travel should also include antioxidants. Astronauts are exposed to numerous sources of oxidative stress, including radiation, elevated oxygen exposure during extravehicular activity, and physical and psychological stress. Elevated levels of oxidative damage are related to

increased risk for cataracts, cardiovascular disease, and cancer. Many ground-based studies show the protective effects of antioxidants against oxidative damage induced by radiation or oxygen. Balancing the diet with foods that have high levels of antioxidants would be another ideal countermeasure because it should have minimal side effects on crew health. Antioxidant supplements, however, are often used without having data on their effectiveness or side effects. High doses of supplements have been associated with bone and cardiovascular problems, but research on antioxidant effects during space flight has not been conducted.

Much work must be done before we can send crews on exploration missions. Nutrition is often assumed to be the simple provision of food items that will be stable throughout the mission. As outlined briefly above, the situation is much more complex than food provision. As explorers throughout history have found, failure to truly understand the role of nutrition can be catastrophic. When humans are in environments unlike any they have seen before, this is more true than ever.